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ABSTRACT

The use of row/column scanning, a technique for accessing a large number of selections with a single volitional action, is considered for individuals with disabilities. It is explained that such a scanning approach is particularly useful for those with only one volitional action, or those, such as people with cerebral palsy, who have pointing skills but need access to devices at all times without expending excess energy. Essentials for row/column scanning are listed, and common oversights are explained, including inefficient display panel layouts. The design of a more efficient row/column scanning device is described, and advantages (such as consistency) and disadvantages (such as the need for sophisticated tracking skills on the user's part) of the technique are noted. (CL)

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AN IMPROVED ROW/COLUMN SCANNING SYSTEM

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ABSTRACT

Row/Column scanning is an efficient technique for any technology requiring spelling by nonspeaking persons. Several computer access devices have been developed using this single switch user system. In this paper, the essentials of row/column scanning devices are outlined. The advantages and disadvantages of the use of these devices by persons with disabilities are examined.

Introduction to Row/Column Scanning

Row/Column Scanning is a fairly rapid and very powerful technique for accessing a large number of selections with a single volitional action.

The user must have very good visual tracking skills and not be susceptible to uncontrolled reflex action caused by the strobing lights.

The individuals that have the most to gain by the use of Row/Column Scanning devices are those with only one volitional action (like ALS victims) or those who, although they have pointing skills, need access to devices at all times without expending excess energy (like some with Cerebral Palsy). These "single switch users" have nothing without some type of scanning access technique. Whatever is gained is significant, namely an infinite increase in capability. Any gain after that is gravy.

The variety of needs of the single switch user include communication, mobility, and environmental control. They need these for education, employment, acts of daily living, and a little dignity for an existence where it's generally denied.

There is no doubt that systems could be accessed more quickly by direct means such as pointing (with body parts, body held or worn tools like mouth sticks, eye gaze, remote pointers like light beams, etc.), or by an encoded direct means such as Morse Code. But usually, these tasks cannot be performed except under specific circumstances.

We must always keep in mind that although scanning techniques are relatively slow, they are consistent and effective. A user will never be a conversationalist at 200 plus words a minute, but may become an effective communicator at 6 plus

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words a minute.

Essentials for Row/Column Scanning

There are some essentials for effective use of a Row/Column Scan device:

1. The device must be designed with an understanding of the criteria of Row/Column Scanning: i.e, the presentation of the scanning display and the layout of information on the display panel are crucial.
2. The technique for use of such a system needs to be taught to the user from the beginning.

The fundamentals for a proper Row/Column Scanning device were functionally presented in the Tufts Interactive Communicator (TIC) developed by R. A. Foulds et al., in the early 1970's. A number of matrix scanning devices were available before that time and some have emerged since. Few, however, followed the guidelines that were in place in the TIC.

Qualifier:

The following comments are specifically pointing out shortcomings in alternate systems. There are valid reasons for the systems to be the way they are. This is only an attempt to clarify the design characteristics of efficient Row/Column scanning devices.

The most critical oversight of Row/Column Scanners is the presentation of only one light at a time during the scan of both the rows and the columns. The user's tracking skills to select an item from the matrix becomes limiting.

The second oversight is to present the user with only one row at a time, and to then scan that row. In this case, motor reaction time to the changing visual presentation of information is restrictive.

The third area of concern is the continual changing of the display to apply predictive techniques in an attempt to reduce overall selection time. These procedures detract from the learned experiences of a fixed display while also increasing reaction time as described above.

The severest violation to effective Row/Column Scanning is the display panel layout. There seems to be great hesitation to deviate from the 'norm'. The use of straight alphabet (A, B, C, etc.) and the typewriter (Q, W, E, R, T, etc.) layouts abound. It has been proven over and over again that these layouts are as much as 40% slower than a Frequency of Use layout.

"Well then...," how did the operate?

The entire matrix was always in view. All the lights of each row were presented during Row Scanning (the entire row was illuminated simultaneously). After selection of a row, each light in that row illuminated sequentially until one was selected. The selected light flashed and Row Scanning resumed. The flashing period was a confirmation and correction time wherein the selection was negated if the operating control was actuated.

The alphabet layout was Frequency of Use with most common characters in the upper left corner and numbers neatly grouped for easy reference.

The user would fixate on the character to be selected and NOT ON THE FLASHING LIGHTS. The operating switch would be actuated when the desired character was illuminated during Row Scan and, without looking away from the desired character, the user waited for it to illuminate a second time (during Column Scan) to make the final selection. There was ample time during the confirmation period to locate the next selection.

These characteristics were subsequently plagiarized for use in the

ZYGO model 100 Communication System. Observation of users showed without a doubt that scanning speeds faster than .25 secs/step were possible, even by those with severe athetoid cerebral palsy or advanced A.L.S.

The actual output (in words per minute) wasn't as high as indicated. Although the scan speeds were high, so was the false selection/correction activity. It was difficult for most uses to 'catch' the first rows or first columns after switch actuation. The alternatives were to either wait for the scan to wrap around and catch the row or column on the second pass, or to actuate the switch multiple times to force the scan back to the beginning without making an actual selection.

Another approach to assist the user was to leave the first row and the first column blank; the user couldn't get to them anyhow. This defeats the entire concept of the layout.

Design of a More Efficient Row/Column Scanning Device

The primary considerations, therefore, in designing a Row/Column Scanning 'keyboard' for computer access by profoundly physically handicapped individuals were a way to reduce the effects of missing the early rows and columns and to pay considerable attention to the information layout.

The Scan

After careful observation of a number of Model 100 users it was determined that there appeared to be a reaction time to actuating a control switch to select the early rows and columns. Furthermore, the reaction time seemed to exist with everyone, those who were able bodied with good reaction as well as those who were physically disabled. And, it didn't matter what the scan speeds were; while working at one's best speed those first rows remained elusive.

Also, it seemed that when the scan was in its 'steady state', that is continuously scanning, each individual could catch the desired selection with considerable accuracy.

The reaction time was not to the steady state scan...it was to the change in presentation. When the row was selected, the body needed to react to the new presentation and it wasn't primed to do so. Even more prominent was the change from the flashing confirmation to the top row.

The solution was to provide a "non-linear presentation" (Patent Applied For). The scan, rather than be uniform with the timing of each step the same as the one before, was slowed down after each actuation of the control switch and gradually increased to the preset steady state rate.

If the steady state time per scan is 't', then after an entry strobe the first row of lights would remain lighted for a time greater then 't', like 1.5't'. The next row would remain on shorter time, and so on until the fifth row, were the scan would revert to 't' time per step.

Faster scanning speeds can be used with this technique without the customary missing of the early rows and columns. It is obvious that the selection time for a perfect user would be longer than without the added delays, but for the imperfect average user, overall selection time is greatly improved due to the reduction of the error/correction selections.

The Display Panel

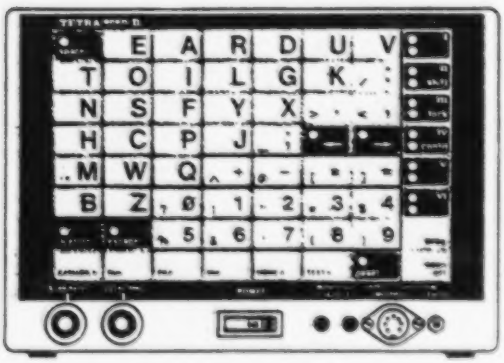
For purely electronic considerations, the display was restricted to an 8 x 8 matrix. Multi-levels were necessary to accommodate even the barest of selections. The alpha layout was the easiest: stay with the TIC layout. Since selection of levels and operational functions seemed to be less important than the characters, they were delegated

to the eighth column, with the fundamental level at the top, in the shortest time to access position.

As in the TIC layout, the numbers were to take a cleanly formatted appearance since they have no Frequency of Use order. Also, for similar reasons, the mathematical functions were neatly grouped adjacent to the numbers.

The Return key was put in the closest space available at the outside of the alpha pattern since it is the most used computer key. The punctuation and the other computer functions filled in the gaps.

Levels I, then, contains lower case characters, primary punctuation, numbers, and math functions. Level II, just as with the computer keyboard, contains upper case characters and the other punctuation and symbols (and a bonus of six function keys in row eight). Level IV is the control level and functions just as on the computer. Levels III, V, and VI (and the six squares in the bottom row of Level I) are user-programmable.



Frequency of Use Research

ZYGO Industries, Inc. has undertaken the development of a program for the APPLE II to determine effectiveness and efficiency of various display panel configurations.

At present, the program allows the introduction and storage of any text and any alpha-numeric pattern (called the "board"). The program will process text with any board and display the number of characters in the text, the number of selections that needed to be made, a normalized time to have scanned the text, and a unit of measure (the normalized time divided by the number of selections) for reference.

The program then provides the quantity in the text of each item on the board to that ranking.

Of the text tried, improvements to the TIC layout remained below 1%.

Future refinements of this program will include the ability to work with multi-levels and include all the functions on the display panel. Although the present program allows the use of blends up to four characters to be in the board, the future versions will allow larger groups and phrases.

Advantages of Row/Column Scanning

1. Consistency. There is an acquired skill in using a Row/Column Scan device much like that of a typist. The location of elements to be selected is always the same and, more importantly, the timing for access is always the same. For example, let's look at spelling the words that contain the letter 'e' in this sentence alone. The 'e' follows 'space', 'l', 'w', 's', 'h', 'b', 'p', 'h' and 'l' again, 't', the 'apostrophe', 's' and 't' again, and then 'n'. If the sentence was being directly selected from a keyboard with one finger there would be the consistency of location, but the motions to get to the 'e' would be all over the keyboard. Realize that with Row/Column Scanning, the time to select each 'e' would be exactly the same regardless of what preceeded it. This speeds up the selection process with improved accuracy as a user gains experience.

2. Positioning Insensitive. Single switch use allows operation from virtually any position, and from varied positions, with similar

ease. For someone with reliable head control it may be practical to use a head actuated switch while sitting in a wheelchair, a different switch while in bed, still another from the therapy mat. Someone with lower extremity capability might use multiple switches that do the same thing (in parallel). They could be arranged for knee action and foot action, in order to reduce the fatigue of using either set of muscles while allowing continued use of the scanning device.

Direct Selection techniques require proper positioning to the device in order to be effective. That severely limits the potential operating time of the majority of users.

3. Exercise. The continued use of a single switch strengthens the associated muscles to where users can continue to function for prolonged periods, not only daily but for extended years.

4. Learning Time. The technique for Row/Column Scanning is straightforward and easily learned in a short time (sometimes it's instantaneous). Others in the user's environment could also interact with the scanning device (i.e., for assistance in arranging programmed messages). The user needs only to have a switch positioned and the scanning device in view in order to operate it.

Disadvantages of Row/Column Scanning

1. Tracking Skills. The user must have tracking skills that are sophisticated enough to follow the scanning lights and actuate an operating control in concert with the lights. Very poor tracking skills that cannot be improved should preclude the use of a Row/Column Scanning device. (A Linear Scanning device might be appropriate).

2. Visual Skills. The user must have eyesight good enough to see the lights as well as the information contained within the auditorily, i.e., a person or device can present rows and columns verbally with selections made by cues from the user. In this case the user's auditory skills and ability to comprehend the auditory cues would apply).

3. Strobing. The strobing lights may cause undesired seizure effects in some individuals. This effect must also be considered for others in the environment of the user. Although the user may not be affected, others who may see the device might be.

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